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(54) **APPARATUS FOR INJECTING A REAGENT INTO A STREAM OF RINSE FLUID**

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(58) **Field of Search** 4/432, 224, 222, 4/222.1, 223, 225.1, 226.1, 320, 321, 431–433; 222/133; 417/440; 137/565

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B1 4,713,847	5/1996	Oldfelt et al.	4/316

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(57) **ABSTRACT**

Apparatus for injecting a reagent into a stream of pressurized rinse fluid delivered to a vacuum toilet. The apparatus is pressure-operated in response to the flow of pressurized rinse fluid, thereby eliminating the need for electric outlets or controls. The apparatus includes an orifice located in a main conduit upstream of a reagent discharge outlet. The orifice reduces the pressure of the rinse fluid thereby to unload a check valve which controls injection of the reagent into the rinse fluid stream. In addition, the volume of a pump chamber for holding reagent is reduced to ensure that the pump maintains its prime. Furthermore, the piping leading into the pump chamber has a relatively uniform inside surface and a tapered insert is used to reduced the cross-sectional area of the reagent extreme, thereby directing air bubbles through the pump chamber.

29 Claims, 2 Drawing Sheets

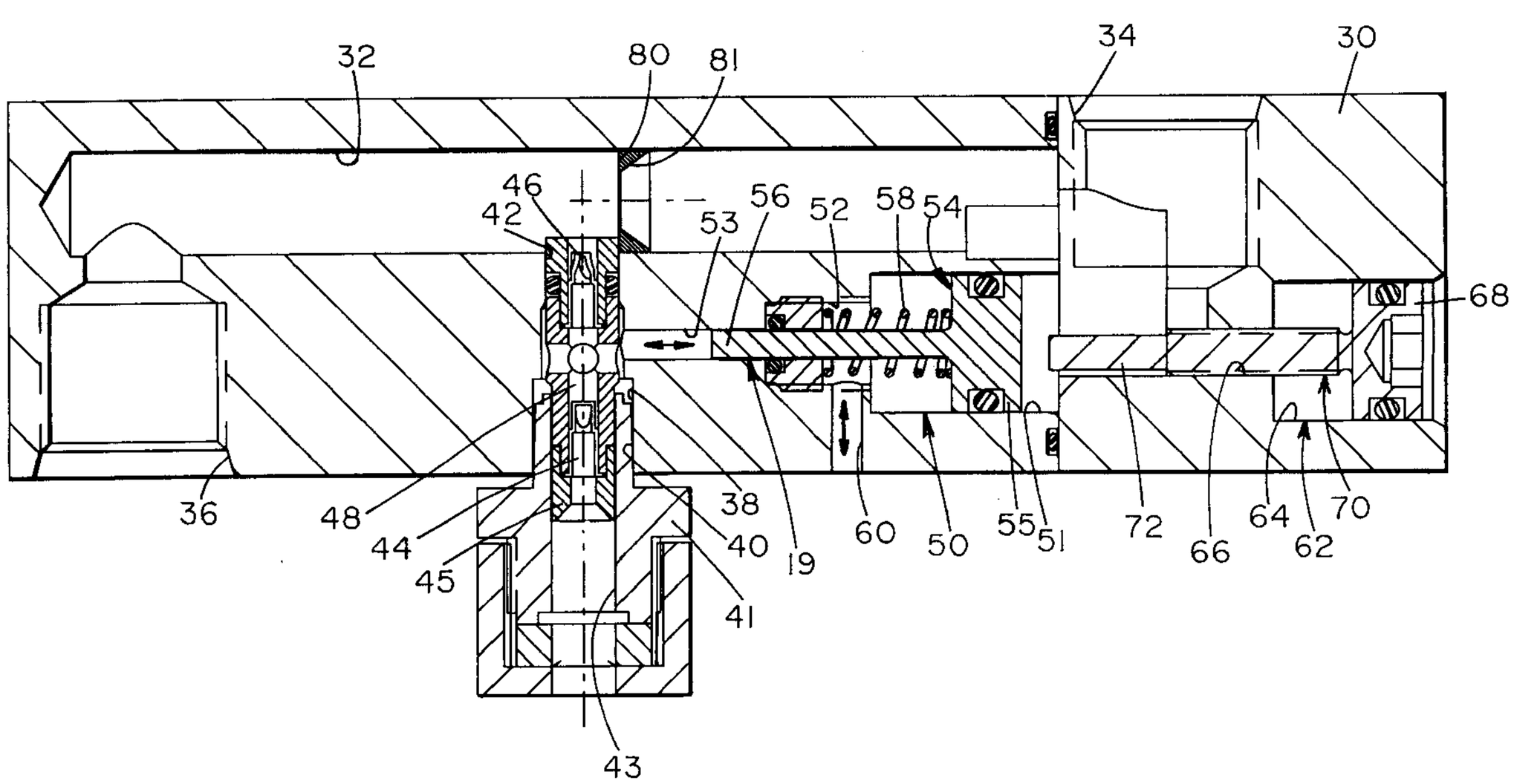
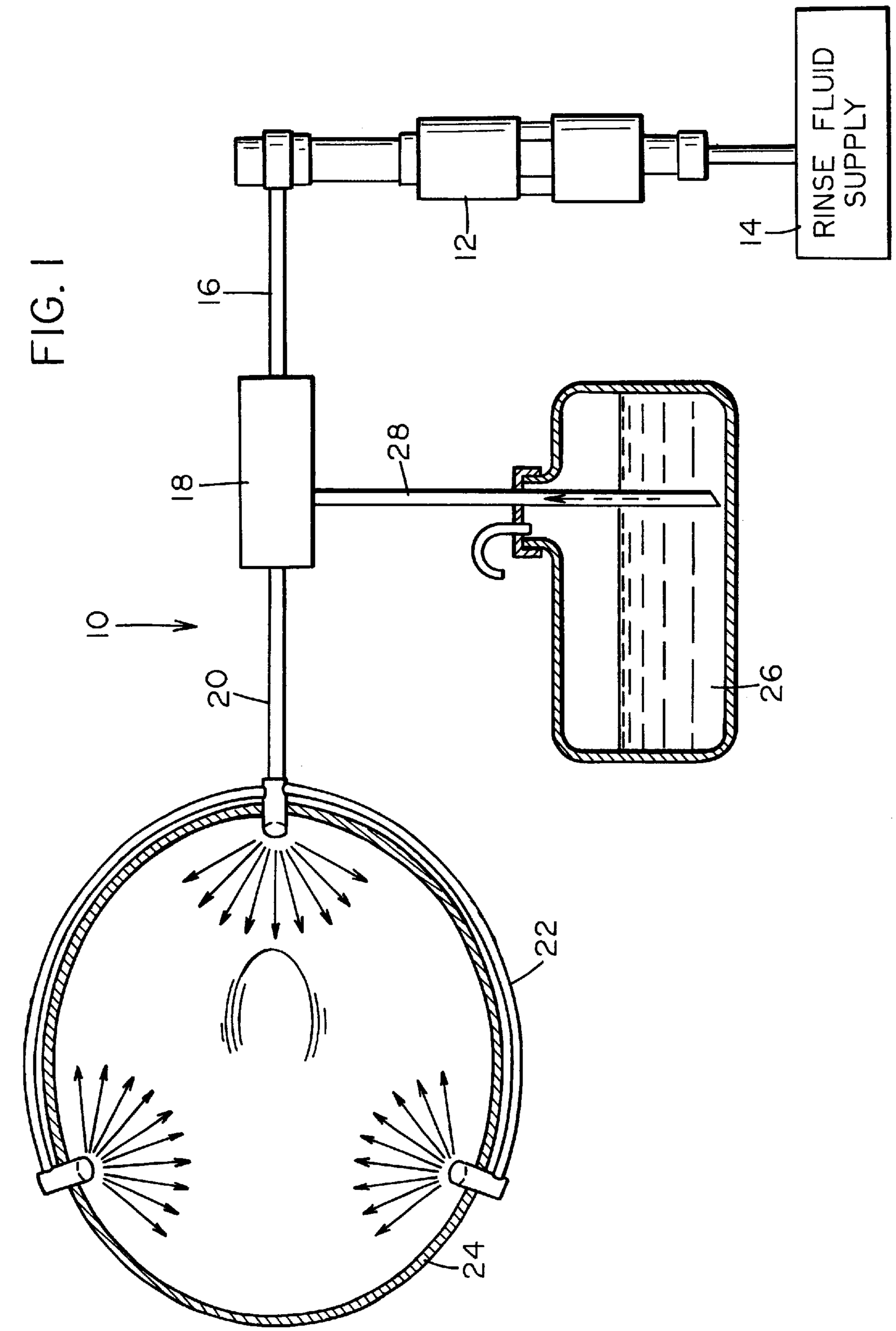


FIG. 1



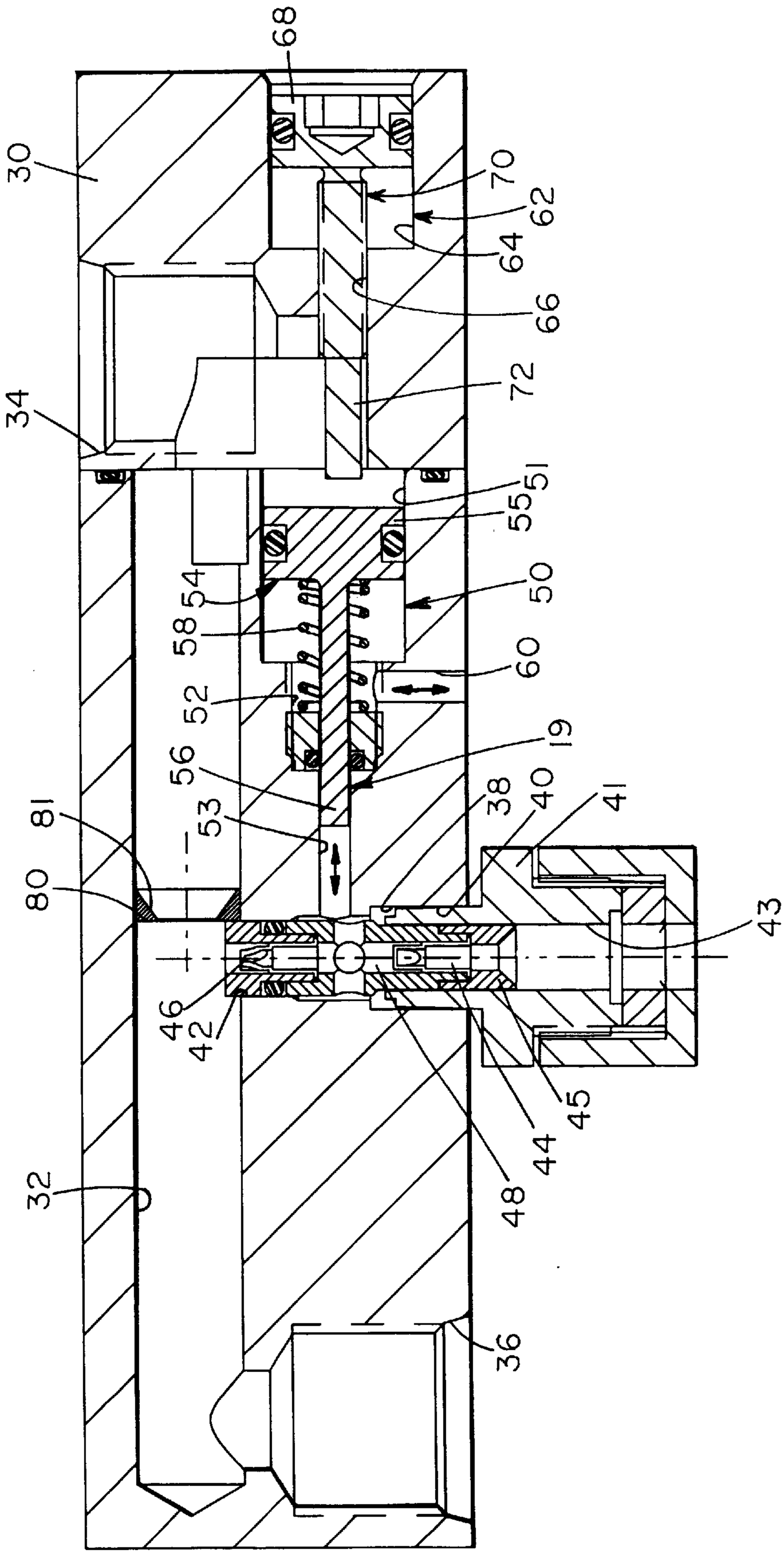

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FIG. 2

APPARATUS FOR INJECTING A REAGENT INTO A STREAM OF RINSE FLUID

FIELD OF THE INVENTION

The present invention generally relates to vacuum toilets, and more particularly to rinse fluid systems used in vacuum toilets.

BACKGROUND OF THE INVENTION

Vacuum toilets having rinse fluid systems are generally known in the art. Such vacuum toilets generally include a bowl having an outlet connected by a discharge pipe to a vacuum source, which generates a vacuum level in the discharge pipe. A discharge valve disposed between the toilet outlet and the discharge pipe controls when vacuum is present in the toilet bowl. When the valve is open, a pressure differential created by the vacuum at the bowl outlet and atmospheric pressure inside the toilet bowl pushes material present in the bowl into the discharge pipe.

It is common for such vacuum toilets to provide a rinse fluid system which rinses the surface of the bowl while the discharge valve is open. The rinse fluid systems typically include a spray ring which extends around the rim of the toilet bowl and is formed with nozzles. The nozzles are positioned so that the entire inside surface of the bowl is rinsed when the spray ring is connected to a source of rinse fluid. A problem associated with such rinse fluid systems is the build-up of deposits in the nozzles. Certain materials, such as calcium carbonate, are dissolved in the rinse water. When rinse water remains in the nozzle, it eventually evaporates, leaving a calcium carbonate residue in the toilet bowl and the nozzles. Consequently, the surface of the toilet bowl may become roughened thereby reducing the efficiency with which waste is removed during the flushing operation. In addition, the residue may clog the nozzles, thereby causing incomplete rinsing of the toilet bowl.

In many vacuum toilet system applications, very little rinse fluid is used with each flush, and a very large volume of air passes through the system during each flush. As a result, a hard plaque may build up on the internal surfaces of the discharge pipe and holding tank. While the plaque may be removed using acid, it may not be safe to do so in certain applications, such as vacuum toilets used on aircraft.

It is further known to introduce a chemical reagent into the rinse fluid of a conventional flush toilet for sanitizing the toilet bowl at each flush. This may be done by hanging a cake of water-soluble material in the toilet tank. However, to the best of applicants' knowledge, a similar technique has never been applied to vacuum toilet systems, due to the need for an electric pump to introduce the chemical reagent into the rinse fluid. The need for an additional electrical outlet is a particular disadvantage with respect to retrofit applications such as on aircraft. Further, the electric pump would require controls, which would also require modification of the flush control unit of the vacuum toilet.

Commonly owned U.S. Pat. No. 5,692,250 to Oldfelt et al. discloses a vacuum toilet system in which a chemical reagent is introduced into a rinse water supply during each flush. The system uses a pressure-actuated pump which operates in response to the presence of pressurized rinse fluid, thereby to inject chemical reagent into the stream of rinse of fluid. As a result, the puLnp does not require additional electrical outlets or control lines.

While this system generally addresses many of the problems outlined above, applicants have found this system

difficult to implement. More specifically, applicants have found that the check valves used to introduce the chemical reagent into the rinse fluid stream are susceptible to collapse under the pressure of the rinse fluid, thereby rendering reagent injection difficult. In addition, the chemical injection pump is susceptible to losing its prime due to the collection to air bubbles both in a pump chamber and upstream of the check valves. As described in the '250 patent, the pump includes a dual-headed piston disposed inside a housing. When the piston moves in a first direction, it draws reagent into a small diameter portion of the housing. When the piston moves in a second direction, the reagent in the small diameter portion is ejected into the rinse fluid stream. Air bubbles entrapped in the reagent may be drawn toward the chemical pump during operation. The air bubbles may aggregate at irregular surfaces in the reagent supply pipe, such as at shoulders, ledges, and corners, to form an air pocket which causes hydraulic lock of the reagent. In addition, air bubbles passing through the first check valve may collect in the pump chamber to form another air pocket. The air pocket inside the pump chamber may be so large that it is not purged through the second check valve with a single stroke of the pump, thereby causing the pump to lose its prime.

SUMMARY OF THE INVENTION

In accordance with certain aspects of the present invention, an apparatus is provided for injecting a reagent from a reagent supply into a stream of pressurized rinse fluid from a rinse fluid supply. The apparatus comprises a main conduit having an inlet adapted for fluid communication with the rinse fluid supply and an outlet. A reagent conduit has an inlet adapted for fluid communication with the reagent supply and an outlet in fluid communication with a downstream point of the main conduit. A first valve is positioned in an upstream portion of the reagent conduit and a second valve is positioned in a downstream portion of the reagent conduit, the first and second valves defining a pump chamber portion of the reagent conduit therebetween. A pressure actuated pump is provided having an actuating end in fluid communication with the rinse fluid supply and a pumping end in fluid communication with the pump chamber portion. The pressure actuated pump is biased toward a first position in which the reagent is drawn through the first valve and into the pump chamber portion from the reagent supply, and is movable to a second position in response to an actuating force generated by the pressurized rinse fluid contacting the actuating end, in which the reagent in the pump chamber portion is discharged through the second valve and reagent conduit outlet. A pressure reducer is disposed in the main conduit upstream of the downstream point.

In accordance with additional aspects of the present invention, an integrated apparatus is provided for injecting reagent from a reagent supply into a pressurized stream of rinse fluid from a rinse fluid supply. The apparatus comprises a solid housing body with a main bore formed in the housing body, the main bore having an inlet adapted for fluid communication with the rinse fluid supply, and an outlet. A reagent bore is formed in the housing body and has an inlet adapted for fluid communication with the reagent supply and an outlet in fluid communication with a downstream point of the main bore. A first valve is positioned in an upstream portion of the reagent bore and a second valve positioned in a downstream portion of the reagent bore, the first and second valves defining a pump chamber portion of the reagent bore therebetween. A pump bore is formed in the

housing body, the pump bore having a large bore section in fluid communication with an upstream point of the main bore and a small bore section in fluid communication with the pump chamber portion of the reagent bore. A unitary piston is disposed in the pump bore, the unitary piston having a large diameter piston head disposed in the large bore section and a small diameter piston head disposed in the small bore section. The unitary piston is biased toward the large bore section to draw reagent through the first valve and into the pump chamber portion of the reagent bore, the pressurized rinse fluid contacting the large diameter piston head to drive the unitary piston toward the small bore section, thereby pushing reagent through the second valve and reagent bore outlet. A pressure reducer is disposed in the main bore between the upstream and downstream points.

In accordance with still further aspects of the present invention, an apparatus is provided for injecting a reagent from a reagent source into pressurized rinse fluid from a rinse fluid source and delivering the rinse fluid and reagent to a vacuum toilet having a bowl. The apparatus comprises a rinse fluid valve having an inlet adapted for fluid communication with the rinse fluid source and an outlet. A main conduit is provided having an inlet in fluid communication with the outlet of the rinse fluid valve, and an outlet. A reagent conduit has an inlet adapted for fluid communication with the reagent source and an outlet in fluid communication with a downstream point of the main conduit. A first valve is positioned in an upstream portion of the reagent conduit and a second valve is positioned in a downstream portion of the reagent conduit, the first and second valves defining a pump chamber portion of the reagent conduit therebetween. A pressure actuated pump has an actuating end in fluid communication with the rinse fluid source and a pumping end in fluid communication with the pump chamber portion. The pressure actuated pump is biased toward a first position in which the reagent is drawn into the pump chamber portion from the reagent source, and is movable to a second position in response to an actuating force generated by the pressurized rinse fluid contacting the actuating end, during which the reagent in the pump chamber portion is discharged through the reagent conduit outlet. A pressure reducer is disposed in the main conduit upstream of the downstream point, and a discharge nozzle is disposed inside the toilet bowl and has an inlet in fluid communication with the outlet of the main conduit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically illustrates a vacuum toilet system embodying certain aspects of the present invention.

FIG. **2** is an enlarged side elevation view, in cross section, of an integrated device for injecting reagent into a stream of rinse fluid, in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A vacuum toilet system **10** incorporating apparatus for injecting a reagent into a stream of pressurized rinse fluid is illustrated in FIG. **1**. The illustrated system includes an integrated vacuum breaker and solenoid valve **12** of the kind described in U.S. Pat. No. 4,811,754, the disclosure of which is incorporated by reference herein, having an inlet connected to a supply of pressurized rinse fluid **14**. An outlet of the valve **12** is connected by a rinse fluid supply pipe **16** to an integrated device **18** housing a reagent pump **19** for introducing a reagent to the rinse fluid, as described in greater detail below. An outlet of the integrated device **18** is connected by a supply pipe **20** to a spray ring **22** disposed inside the bowl of a vacuum toilet **24**. The vacuum toilet system **10** further comprises a reagent source **26** connected by a reagent supply pipe **28** to a reagent inlet of the integrated device **18**.

As best shown in FIG. **2**, the integrated device **18** comprises a solid housing body **30**. A main bore or conduit **32** is formed in the housing body **30** and has an inlet **34** attached to the rinse fluid supply pipe **16** and an outlet **36** attached to the supply pipe **20**. The housing body **30** is also formed with a reagent bore **38** defining a reagent inlet **40** connected to the reagent supply pipe **28** and a reagent outlet **42** in fluid communication with the main bore **32**.

A first check valve **44** is disposed in an upstream portion of the reagent bore **38** and is oriented to allow fluid to flow into the reagent bore while preventing reverse flow. A second check valve **46** is disposed in a downstream portion of the reagent bore **38** and is oriented to allow flow toward the reagent outlet **42** while preventing a reverse flow. In the preferred embodiment, the first and second check valves **44**, **46** are pressure sensitive, Such as duckbill-style check valves, which have a flexible tip acting as the valve member. The flexible tip of each valve expands or contracts according to a pressure differential across the member. In each of the first and second check valves **44**, **46**, the flexible tip will contract to allow flow when the pressure is greater upstream of the valve. Conversely, the flexible tip will expand to prevent flow when the downstream pressure is greater. A portion of the reagent bore **38** extending between the first and second check valves **44**, **46** defines a pump chamber **48** into which reagent is drawn and from which reagent is discharged into the rinse fluid stream.

The housing body **30** is further formed with a pump bore **50**. The pump bore **50** has a large diameter bore section **51**, an intermediate diameter bore section **52**, and a small diameter bore section **53**. As shown in FIG. **2**, the large bore section **51** fluidly communicates with an upstream point of the main bore **32**, while the small bore section **53** fluidly communicates with the pump chamber section **48** of the reagent bore **38**. A unitary piston **54** is disposed inside the pump bore **50** and has a large diameter piston head **55** positioned inside the large diameter bore section **51** and a small diameter piston head **56** positioned inside the small diameter bore section **53**. The large and small diameter piston heads are suitably sealed with the pump bore **50** to prevent passage of fluid therebetween. A compression spring **58** is disposed inside the pump bore **50** and engages a rear face of the large diameter piston head **55** to bias the unitary piston **54** toward the large bore section **51**. An air vent bore **60** extends from the intermediate diameter bore section **52** to an exterior of the housing body **30**. The air vent bore **60** allows air to enter into and escape from a section of the pump bore **50** located between the large and small diameter piston heads **55**, **56** as the unitary piston **54** actuates.

A coupling **41** is provided for attaching the reagent supply pipe **28** to the reagent inlet **40**. As shown in FIG. **2**, the coupling **41** preferably has a straight inner bore **43** to minimize flow disturbances as the reagent enters the inlet **40**. As best shown in FIG. **2**, the inner bore **43** has a diameter which is greater than that of the pump chamber **48**. To eliminate a potential area where air bubbles may accumulate, a tapered insert **45** is disposed inside the coupling **41** to gradually decrease the area through which the reagent flows. The tapered insert **45** eliminates a ledge or step that would otherwise tend to accumulate air bubbles, and instead directs air bubbles through the first check valve **44**. Furthermore, the pump chamber **48** preferably has a

relatively small diameter in comparison to the active portion of the small diameter bore section **53**. The active portion is defined herein as the space through which the small diameter piston head **56** travels during a full stroke. By reducing the volume of the pump chamber **48**, the unitary piston **54** is more likely to purge any air collected in the pump chamber in a single stroke, thereby ensuring that the pump does not lose its prime.

According to the illustrated embodiment, a stroke adjustment bore **62** is also formed in the housing body **30** and comprises an adjustment section **64** and a pass-through section **66**. The adjustment section **64** is preferably threaded to receive the head **68** of an adjustment screw **70**. A pin **72** extends from the head **68** and through the pass-through section **66** so that an end of the pin **72** projects into the large diameter bore section **51** of the pump bore **50**. Accordingly, it will be appreciated that the pin **72** of the adjustment screw **70** limits the travel of the unitary piston **54** toward the large diameter bore section **51** by providing a stop surface positioned to engage the front face of the large diameter piston head **55**. The head **68** of the adjustment screw **70** may be positioned along the threaded adjustment section **62** to vary the position of the stop.

It will be appreciated that the stroke of the unitary piston **54** determines the metered volume or dose delivered by the reagent pump. In a preferred embodiment, the volume of the dose is greater than the volume in the pump chamber **48** to ensure that any air present in the pump chamber is purged with a single stroke of the unitary piston **54**. The adjustment screw **70** limits the stroke of the piston **54** and may be repositioned to alter the dose volume. Thus, the active portion of the small diameter bore section **53** is also altered when the adjustment screw **70** is repositioned.

According to certain aspects of the present invention, a pressure reducer is disposed in the main bore **32** upstream of the reagent outlet **42**. As best shown in FIG. **2**, the pressure reducer comprises an orifice **80** having an inner diameter **81** which is less than the diameter of the main bore **32**. As rinse fluid flows through the orifice **80**, the reduced diameter **81** produces a pressure drop in the fluid downstream of the orifice **80**. As a result, the rinse fluid pressure present at the reagent outlet **42** decreases, thereby reducing the likelihood that the second check valve **46** will collapse. In a preferred embodiment, the shape and size of the orifice **80** has a coefficient of flow of approximately 0.5 to 0.75. In a most preferred embodiment, the orifice **80** is a Borda-style orifice. As will be appreciated from a general understanding, of fluid dynamics, the fluid stream flowing through the orifice **80** develops a smaller cross-sectional area known as the vena contracta. In a preferred embodiment, the orifice **80** is positioned so that the vena contracta is adjacent the reagent outlet **42** so that the pressure drop created by the orifice **80** is greatest in this area.

In operation, the valve **12** temporarily opens in response to flush command to deliver pressurized rinse fluid to the integrated device **18**. The rinse fluid enters the main bore **32** and travels through the orifice **80** before existing from the outlet **36**. The pressurized rinse fluid contacts the front face of the large diameter piston head **55** to generate an actuating force on the unitary piston **54**. The actuating force overcomes the bias force of the spring **58** to drive the unitary piston **54** into the small diameter bore section **53** of the pump bore **50**. The large bore section **51** preferably communicates with the main bore **32** upstream of the orifice **80** to utilize the greater pressure level of the rinse flush.

As the unitary piston **54** is pushed into the small bore section **53**, fluid present in the active portion of the small diameter bore section **53** is pushed into the pump chamber **48**. The pressure inside the pump chamber **48** increases so that the first check valve **44** closes while the second check valve **46** opens to discharge reagent through the outlet **42**. Any air bubbles present in the pump chamber **48** are discharged with the reagent due to the relatively large active portion of the small bore section **53**.

The mixture of rinse fluid and reagent is delivered to the spray ring **22** where it is discharged into the toilet bowl. When the valve **12** closes to stop the flow of rinse fluid, the spring **58** returns the unitary piston **54** to the initial position. As the unitary piston **54** moves in this direction, it reduces the pressure inside the pump chamber **48** thereby closing the second check valve **46** and opening the first check valve **44**. With the first check valve **44** opened, reagent is allowed to flow into the pump chamber until the unitary piston **54** stops moving. With the piston **54** back in the initial position and the pump chamber **48** filled with reagent, the pump **19** is ready for a subsequent rinse operation.

As described above and shown in the drawings, the main bore, reagent bore, and reagent pump are all incorporated into the integrated device **18**. The integrated device is compact, light, and may be mounted directly onto a vacuum toilet. While the integrated device is preferred, it will be appreciated that each of the components may be provided separately without departing from the scope of the present invention.

The liquid reagent may comprise one or more components which remove plaque, inhibit the formation of deposits, or provide other benefits in a vacuum toilet environment. This includes all of the components discussed in U.S. Pat. No. 5,692,250 to Oldfelt, which is incorporated herein by reference.

From the above, it will be appreciated that the present invention provides new and improved apparatus for injecting a reagent into a stream of pressurized rinse fluid. The apparatus includes an orifice located in a main conduit upstream of a reagent discharge outlet. The orifice reduces the pressure of the rinse fluid thereby to unload a check valve which controls injection of the reagent into the rinse fluid stream. In addition, the volume of a pump chamber for holding reagent is reduced to ensure that the pump maintains its prime. Furthermore, the piping leading into the pump chamber has a relatively uniform inside surface and a tapered insert is used to reduce the cross-sectional area of the reagent flow stream, thereby directing air bubbles through the pump chamber.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications would be obvious to those skilled in the art.

What is claimed is:

1. Apparatus for injecting a reagent from a reagent supply into a stream of pressurized rinse fluid from a rinse fluid supply, the apparatus comprising:

a main conduit having an inlet adapted for fluid communication with the rinse fluid supply and an outlet;

a reagent conduit having an inlet adapted for fluid communication with the reagent supply and an outlet in fluid communication with a downstream point of the main conduit;

a first valve positioned in an upstream portion of the reagent conduit and a second valve positioned in a downstream portion of the reagent conduit, the first and second valves defining a pump chamber portion of the reagent conduit therebetween;

a pressure actuated pump having an actuating end in fluid communication with the rinse fluid supply and a pumping end in fluid communication with the pump chamber portion, the pressure actuated pump being biased toward a first position in which the reagent is drawn through the first valve and into the pump chamber portion from the reagent supply, the pump being movable to a second position in response to an actuating force generated by the pressurized rinse fluid contacting the actuating end, during which the reagent in the pump chamber portion is discharged through the second valve and reagent conduit outlet; and

a pressure reducer disposed in the main conduit upstream of the downstream point.

2. The apparatus of claim **1**, in which the actuating end of the pressure actuated pump is in fluid communication with an upstream point of the main conduit, and the pressure reducer is positioned between the upstream and downstream points.

3. The apparatus of claim **1**, in which the actuating end of the pressure actuated pump comprises a large volume chamber and the pumping end of the pressure actuated pump comprises a small volume chamber, the pressure actuated pump comprising a unitary piston having a large diameter piston head disposed in the large volume chamber and a small diameter piston head disposed in the small volume chamber.

4. The apparatus of claim **3**, further comprising a compression spring attached to a back face of the large diameter piston head for biasing the unitary piston toward the first position.

5. The apparatus of claim **1**, in which the pressure reducer comprises an orifice.

6. The apparatus of claim **5**, in which the orifice has a flow coefficient of between approximately 0.5 and 0.75.

7. The apparatus of claim **1**, in which the orifice is positioned immediately upstream of the reagent conduit outlet.

8. The apparatus of claim **1**, in which the first and second valves comprise check valves.

9. The apparatus of claim **1**, in which the pressure actuated pump displaces a dose volume as the pump moves from the first position to the second position, and the pump chamber has a volume which is smaller than the dose volume.

10. The apparatus of claim **1**, further comprising a coupling attached to the reagent conduit inlet, the coupling defining a flow path which is axially aligned with the pump chamber.

11. The apparatus of claim **10**, in which the coupling has an inner bore having a first diameter, and in which the pump chamber has a second diameter smaller than the first diameter, the apparatus further comprising a tapered insert disposed inside the coupling having a tapered faced extending from the first diameter to the second diameter.

12. An integrated apparatus for injecting reagent from a reagent supply into a pressurized stream of rinse fluid from a rinse fluid supply, the apparatus comprising:

a solid housing body;

a main bore formed in the housing body, the main bore having an inlet adapted for fluid communication with the rinse fluid supply, and an outlet;

a reagent bore formed in the housing body, the reagent bore having an inlet adapted for fluid communication with the reagent supply and an outlet in fluid communication with a downstream point of the main bore;

a first valve positioned in an upstream portion of the reagent bore and a second valve positioned in a downstream portion of the reagent bore, the first and second valves defining a pump chamber portion of the reagent bore therebetween;

a pump bore formed in the housing body, the pump bore having a large bore section in fluid communication with an upstream point of the main bore and a small bore section in fluid communication with the pump chamber portion of the reagent bore;

a unitary piston disposed in the pump bore, the unitary piston having a large diameter piston head disposed in the large bore section and a small diameter piston head disposed in the small bore section;

wherein the unitary piston is biased toward the large bore section to draw reagent through the first valve and into the pump chamber portion of the reagent bore, the pressurized rinse fluid contacting the large diameter piston head to drive the unitary piston toward the small bore section, thereby pushing reagent through the second valve and reagent bore outlet; and

a pressure reducer disposed in the main bore between the upstream and downstream points.

13. The apparatus of claim **12**, further comprising a compression spring attached to a back face of the large diameter piston head for biasing the unitary piston toward the large bore section.

14. The apparatus of claim **12**, in which the pressure reducer comprises an orifice.

15. The apparatus of claim **12**, in which the orifice is positioned immediately upstream of the reagent conduit outlet.

16. The apparatus of claim **12**, in which the first and second valves comprise duckbill check valves.

17. The apparatus of claim **12**, in which the unitary piston displaces a dose volume as the unitary piston is driven toward the small bore section, and the pump chamber portion of the reagent bore has a volume which is smaller than the dose volume.

18. The apparatus of claim **12**, further comprising a coupling attached to the reagent bore inlet, the coupling defining a flow path which is axially aligned with the pump chamber.

19. The apparatus of claim **18**, in which the coupling has an inner diameter, and in which the pump chamber has a bore diameter smaller than the inner diameter of the coupling, the apparatus further comprising a tapered insert disposed inside the coupling having a tapered faced extending from the inner diameter to the bore diameter.

20. Apparatus for injecting a reagent from a reagent source into pressurized rinse fluid from a rinse fluid source and delivering the rinse fluid and reagent to a vacuum toilet having a bowl, the apparatus comprising:

a rinse fluid valve having an inlet adapted for fluid communication with the rinse fluid source and an outlet;

a main conduit having an inlet in fluid communication with the outlet of the rinse fluid valve, and an outlet;

a reagent conduit having an inlet adapted for fluid communication with the reagent source and an outlet in fluid communication with a downstream point of the main conduit;

a first valve positioned in an upstream portion of the reagent conduit and a second valve positioned in a downstream portion of the reagent conduit, the first and second valves defining a pump chamber portion of the reagent conduit therebetween;

a pressure actuated pump having an actuating end in fluid communication with the rinse fluid source and a pump-

ing end in fluid communication with the pump chamber portion, the pressure actuated pump being biased toward a first position in which the reagent is drawn into the pump chamber portion from the reagent source, the pump being movable to a second position in response to an actuating force generated by the pressurized rinse fluid contacting the actuating end, during which the reagent in the pump chamber portion is discharged through the reagent conduit outlet;

a pressure reducer disposed in the main conduit upstream of the downstream point; and

a discharge nozzle disposed inside the toilet bowl and having an inlet in fluid communication with the outlet of the main conduit.

21. The apparatus of claim **20**, in which the actuating end of the pressure actuated pump is in fluid communication with an upstream point of the main conduit, and the pressure reducer is positioned between the upstream and downstream points.

22. The apparatus of claim **20**, in which the actuating end of the pressure actuated pump comprises a large volume chamber and the pumping end of the pressure actuated pump comprises a small volume chamber, the pressure actuated pump comprising a unitary piston having a large diameter piston head disposed in the large volume chamber and a small diameter piston head disposed in the small volume chamber.

23. The apparatus of claim **22**, in which the pressure reducer comprises an orifice.

24. The apparatus of claim **23**, in which the orifice has a flow coefficient of between approximately 0.5 and 0.75.

25. The apparatus of claim **20**, in which the orifice is positioned immediately upstream of the reagent conduit outlet.

26. The apparatus of claim **20**, in which the discharge nozzle comprises a spray ring.

27. The apparatus of claim **20**, in which the pressure actuated pump displaces a dose volume as the pump moves from the first position to the second position, and the pump chamber has a volume which is smaller than the dose volume.

28. The apparatus of claim **20**, further comprising a coupling attached to the reagent conduit inlet, the coupling defining a flow path which is axially aligned with the pump chamber.

29. The apparatus of claim **28**, in which the coupling has an inner bore having a first diameter, and in which the pump chamber has a second diameter smaller than the first diameter, the apparatus further comprising a tapered insert disposed inside the coupling having a tapered faced extending from the first diameter to the second diameter.

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